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Technical Memorandum 80564

Interim Calibration Report for the SMMR Simulator

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(NASA-TM-80564) INTERIM CALIBRATION REPORT
FOR THE SMMR SIMULATOR (NASA) 22 p
HC A02/MF A01 CSCL 14B

N80-12534

G3/43 41474
Unclas

SEPTEMBER, 1979

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

TM 80564

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ABSTRACT

The calibration data obtained during the FALL 1978 NIMBUS-G underflight mission with the Scanning Multichannel Microwave Radiometer (SMMR) simulator on board the NASA CV-990 aircraft have been analyzed and an interim calibration algorithm developed. Data selected for this analysis consisted of in-flight sky, first-year sea ice, and open water observations, as well as ground-based observations of fixed targets while varying the temperatures of selected instrument components. For most of the SMMR channels, a good fit to the selected data set was obtained with the algorithm.

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INTERIM CALIBRATION REPORT FOR THE SMMR SIMULATOR

I. INTRODUCTION

The calibration data obtained during the October - November Nimbus-G underflight mission with the Scanning Multichannel Microwave Radiometer (SMMR) simulator on board the NASA CV-990 aircraft have been analyzed and an appropriate calibration algorithm developed. This algorithm will be used to produce the first set of calibrated microwave radiances for all the underflight missions. It is anticipated that additional adjustments of the constants in the calibration algorithm will be required as the flight data are analyzed and compared with associated surface data, and after additional calibration measurements are carried out in our laboratory.

A number of different algorithms and combinations of calibration data were tried before the most satisfactory one, presented here, was selected. While no attempt to record the less satisfactory algorithms will be made, the pitfalls to be avoided in the future will be discussed.

II. THEORY

1. Normalized Signal

The SMMR simulator radiometers are of the Dicke-type and utilize two internal radiometric references which are calibrated against external sources. Most of the microwave radiances that are encountered in flight fall in-between the references, and a linear interpolation scheme is used to produce calibrated radiance values, expressed as brightness temperatures, T_B 's, in Kelvins.

The radiances observed by the radiometer are those received from the viewing antenna through the radomes, waveguides, and switches, T_R ; from the cold reference, T_C , and from the hot reference, T_H . The radiometric path from the hot reference to the radiometer is all essentially at the same physical temperature (including the switch network), so the radiance is equal to the physical temperature, t_H , of that system, i.e.,

$$T_H = t_H \quad (1)$$

The cold reference, on the other hand, is viewed through a warm switch and waveguide; the radiance is attenuated by the lumped transmissivity of this path, α_c , and supplemented by re-radiation from that loss, at an averaged temperature, βt_H , so that

$$T_c = \alpha_c t_c + (1 - \alpha_c) \beta t_H \quad (2)$$

The loss and re-radiation along the path from the antenna aperture and the radiometer port have several components at different temperatures, so the radiance observed is

$$T_R = \alpha_R \alpha_A \alpha_W \alpha_H T_B + (1 - \alpha_H) t_H + \alpha_H (1 - \alpha_W) t_W + \alpha_H \alpha_W (1 - \alpha_s) t_s + \alpha_H \alpha_W \alpha_s (1 - \alpha_R) t_R \quad (3)$$

where α_R , α_s , α_W , and α_H are the transmissivities of the radome, sled waveguide, cargo or cabin waveguide, and switch network, respectively. Their physical temperatures have corresponding subscripts.

An interpolation of T_R between the values of T_H and T_c can be accomplished using a variable N in the following way:

$$T_R = T_H + (T_c - T_H) N \quad (4)$$

Solving for N ,

$$N = \frac{T_R - T_H}{T_c - T_H} \quad (5)$$

If the amplifiers are linear, then the digitized output signal will be linearly related to any input radiance, i.e.

$$T_i = b_0 + b_1 C_i \quad (6)$$

where $i = C, H$, or R and C_i is the digitized output. Substituting (6) in (5), one obtains N in the form of a normalized signal:

$$N = \frac{C_R - C_H}{C_C - C_H} \quad (7)$$

2. Calibration Equation

It has been found convenient to treat N as the dependent variable during the part of the calibration procedure which deals with the various losses in the system. Substituting Equations (1) – (3) into (5),

$$N = [\alpha_R \alpha_A \alpha_W \alpha_H T_B - \alpha_H t_H + \alpha_H (1 - \alpha_W) t_W + \alpha_H \alpha_W (1 - \alpha_S) t_S + \alpha_H \alpha_W \alpha_S (1 - \alpha_R) t_R] \cdot [\alpha_c t_c + [(1 - \alpha_c) \beta - 1] t_H]^{-1} \quad (8)$$

Equation (8) is non-linear in t_c and t_H . Because losses generally have a temperature-dependent coefficient, it is also non-linear in t_W , t_R , and t_S . Expanding Equation (8) to second order, where appropriate, about nominal values of the $t_i \equiv t_{i0}$,

$$N = \sum_{i=0}^2 \{ a_i T_B^i + b_i (t_H - t_{H0})^i + c_i (t_W - t_{W0})^i + d_i (t_S - t_{S0})^i + e_i (t_R - t_{R0})^i + f_i (t_c - t_{c0})^i \} \quad (9)$$

where the cross-terms have been neglected and no attempt will be made to solve the a_0 through f_2 coefficients in terms of the α_i .

In the absence of appropriate data to determine them, the coefficients e_2 and f_2 in Equation (9) will be assumed equal to zero. All of the intercept values, b_0 through f_0 , are absorbed in a_0 .

Equation (9) can be rewritten in the following more convenient form:

$$T_B = A + BM + CM^2 \quad (10)$$

$$\text{where } M = N - \sum_{i=1}^2 [b_i (t_H - t_{H0})^i + c_i (t_W - t_{W0})^i + d_i (t_S - t_{S0})^i - e_i (t_R - t_{R0}) - f_i (t_c - t_{c0})]$$

In Equation (10), the nonlinearity has been taken into account by expanding to second order in M rather than in T_B as was done in Equation (9). In those cases where $C = 0$ (all channels except 6.6 H&V), $A = a_0 a_1^{-1}$ and $B = a_1^{-1}$.

III CALIBRATION PROCEDURE

In view of the uncertainties discovered in the radiometer calibration targets, the liquid nitrogen-cooled targets were not utilized at all in the calibration procedure; only *difference* equations were employed using the ambient temperature targets and sea ice targets where the high/low level flight data were used. The primary calibration utilized data obtained at a 45° right-bank turn over sea ice near Pond Inlet, where concurrent surface measurements were made, and *one* wing-over maneuver data set which appeared to be of sufficient duration for a sky-look by the radiometers (different wing-overs were used for different channels). The calibration procedure permitted determining some of the coefficients in Equation (9) independently of the others and the rest by a stepwise procedure.

1. Waveguide Coefficients

The data obtained at the airport in Fairbanks using the ambient Eccosorb targets were utilized as follows. The target temperatures were assumed to be constant during each of the tests, and the component temperatures were varied from ambient (near freezing) to nominal operating temperatures by turning on the component heaters. The following relationship was used for each channel:

$$N - N_0 = \sum_{i=0}^2 [c_i \Delta t_w^i + d_i \Delta t_s^i] \quad (11)$$

where N_0 was the normalized signal received when the components were at their nominal operating temperatures. Multiple linear regression in the four variables Δt_w , Δt_w^2 , Δt_s , Δt_s^2 was used on the data obtained during component warm-up (one-minute averages). The results are listed in Table I.

2. Cold Reference Corrections

As the aircraft cabin/cargo pressures vary (with altitude and flight engineer fancy), the boiling point temperature of the liquid nitrogen also varies, usually less than 2K during the course of a flight. The required correction coefficient was obtained as follows: From Equation (7), we can write

$$N = \frac{\delta}{C_c - \gamma} \quad (12)$$

where C_R and C_H are held constant (constant target and hot reference temperatures) during the variation of t_c . t_c was varied by starting the liquid nitrogen dewars at ambient temperature to obtain the normalized signal, N_1 , then filling the dewars to obtain a second signal, N_2 . Thus, the coefficients δ and γ in Equation (12) could be determined. Also recorded were the corresponding signals C_{c1} and C_{c2} .

Since the operating range of t_c is normally small, it is appropriate to expand Equation (12) as follows:

$$\frac{dN}{dt_c} = \frac{\partial N}{\partial C_c} \frac{\partial C_c}{\partial t_c} = \frac{\delta}{(C_c - \gamma)^2} \cdot G \quad (13)$$

$$\text{where } G = \frac{C_{c2} - C_{c1}}{t_{c2} - t_{c1}}$$

$$\gamma = \frac{N_1 C_{c1} - N_2 C_{c2}}{N_1 - N_2}$$

$$\delta = N_1 C_{c1} - N_2$$

Finally, for f_1 (in Equation (10)),

$$f_1 = \frac{\delta G}{(C_c(\text{at } t_c = 77.2K) - \gamma)^2} \quad (14)$$

The values for δ , γ and G are listed in Table II and for f_1 in Table I.

3. Radomes (and lens) corrections

The radome and lens losses were taken into account by obtaining values for the dependent variable $(N - B^{-1} \Delta T_B - \sum_{i=1}^2 (C_i \Delta t_w^i + d_i \Delta t_s^i + f_i \Delta t_c^i))$, i.e. using the variations in t_w , t_s , and t_c , for high and low flight levels over the same target area (t_H was held constant). In general, the radiance of the atmosphere must be taken into account, as follows:

$$\begin{aligned}
T_{BHI} &= \epsilon T_s e^{-\tau} + T_{\uparrow} + k(1-\epsilon) T_{\downarrow} e^{-\tau} + k(1-\epsilon) T_{SP} e^{-2\tau} \\
T_{BLO} &= \epsilon T_s + k(1-\epsilon) T_{\downarrow} + k(1-\epsilon) T_{SP} e^{-\tau} \\
\Delta T_B &= T_{BHI} - T_{BLO} = (e^{-\tau} - 1) [\epsilon T_s + k(1-\epsilon) (T_{\downarrow} + T_{SP} e^{-\tau})] + T_{\uparrow}
\end{aligned} \tag{15}$$

where ϵ is the surface emissivity, τ is the atmospheric opacity, k is a non-specular reflection factor, T_{\uparrow} and T_{\downarrow} are the upwelling and downwelling atmospheric radiances, respectively, and $T_{SP} = 2.7K$.

In the Arctic, $\tau \ll 1$, $T_{\uparrow} \approx T_{\downarrow} \approx \tau T_A$, and T_A is a weighted average of the air temperature in the column. Then Equation (15) becomes

$$\Delta T_B = -\tau [\epsilon T_s + k(1-\epsilon) (\tau T_A + 2.7(1-\tau))] + \tau T_A \approx \tau [T_A - \epsilon T_s] \tag{16}$$

neglecting 2nd order terms.

A flight condition was chosen (Day 315, 1978) in which a surface with high emissivity was encountered -- a mixture of first-year and multiyear ice in MacKenzie Bay -- so that ΔT_B (Equation (16)) was minimized since $\epsilon T_s \approx T_A$. The ΔT_B corrections calculated for the MacKenzie Bay site based on a standard Arctic model atmosphere are shown in Table III. Using the values obtained at high (10^4 m) flight levels and low (150 m) flight levels, the following equation

$$\Delta N - B^{-1} \Delta T_B - c_1 \Delta t_w - c_2 \Delta t_w^2 - d_1 \Delta t_s - d_2 \Delta t_s^2 - f_1 \Delta t_c^2 = e_1 \Delta t_R \tag{17}$$

was used to determine e_1 , listed in Table I. ($\Delta t_H = 0$ for these measurements.) This was done in two stages. In the first, ΔT_B was set equal to zero to obtain a first estimate of e_1 . Then the method of Section 3.5 was used to obtain a first estimate of B . This value of B was then used in Equation (17) to obtain the final value of e_1 .

4. Hot Reference Corrections

If the hot load radiometric reference were held stable throughout a flight and from one flight to the next, no corrections would be required since its steady-state reference value is incorporated into the constants A and B (Equation (10)). However, experience has shown that *different* steady-state values are obtained from one flight to the next and interesting data occur during early flight warm-ups.

The data for the hot reference correction coefficient were obtained at Fairbanks International Airport between flights. As in the previous section, a modified dependent variable was used:

$$\Delta N - c_1 \Delta t_w - c_2 \Delta t_w^2 - d_1 \Delta t_A - d_2 \Delta t_A^2 - e_1 \Delta t_R = b_1 \Delta t_H + b_2 \Delta t_H^2 \quad (18)$$

Multiple linear regression in the independent variables Δt_H and Δt_H^2 was used on one-minute averages of the data obtained during the warm-up of t_H to obtain b_1 and b_2 , which are listed in Table I.

5. The primary calibration constants

If the radiometric reference temperatures and component temperatures were all held steady during the observations, and if the radiometer were linear (not the case for the 4.6 H and 4.6 V), the only constants that would be required are A and B (Equation (10)). Only two known external target temperatures are required to obtain these constants. After a bit of trial and error, the two best radiometric targets for this purpose were deemed to be data obtained in-flight: for the low T_B point, data taken during an aircraft wingover maneuver (fuselage in a horizontal plane, wings in a vertical plane) were used; for the high T_B point, data obtained over first-year sea ice near Pond Inlet, observed during a 45° right-bank turn, were used. Of the 10 wingover maneuvers executed during the mission, only 8 produced useful data for various reasons, and each channel produced its "optimum" output during different wingovers. (See Table IV). The 45° right-bank turn data over the Pond Inlet sea ice were chosen because of the availability of detailed concurrent surface measurements and because the T_B 's of first-year sea ice can be calculated with greater confidence for normal incidence angles. (The aircraft radiometers were pointed 45° to the right of the aircraft nadir.) The data used for this determination are tabulated in Table V.

In the case of the 4.6 H and 4.6 V channels, the two-point calibration did not give good agreement with open water observations (Table VI), where the T_B 's can be calculated with reasonable confidence. The tentative conclusion, which will be tested in the subsequent laboratory tests, is that the 4.6 radiometer is non-linear and so, a third calibration point, a 45° bank right-turn over open

water (Pond Inlet Flight - eastern Baffin Bay) was used (see Table V) to determine A, B, and C from Equation (10).

6. The calibration equation

Equation (10) was used to calibrate the SMMR simulator data from the 1978 Nimbus-7 under-flight mission. The constants are listed in Table I.

III. COMMENTS AND RECOMMENDATIONS

1. General

It is clear that the radome and lens losses are much more significant than intended by their design. The radome and exposed lens temperatures encountered in flight have been deduced from the aircraft housekeeping parameter designated "total air" which is obtained from a thermister mounted in a Pitot tube probe. It is estimated that the aircraft skin temperature is everywhere within 1K of the "total air" value, but no firm evidence is in hand. Also, in the case where *both* radome *and* lens are present, i.e. at 1.7 and 2.8 cm there was no test procedure available to obtain separately their loss correction coefficients, even though individual estimates of their temperatures (which were not always in phase) were available. In the future, direct means of monitoring both lens and radome temperatures must be incorporated, and tests for separating their effects devised.

Also, in the future, improved ambient and cold reference targets are essential, especially since the wingover maneuver data are not very consistent. It may be that the present ambient targets would require simply viewing at normal incidence for sufficient improvement. Wingovers should be continued in the future, but should be executed at least twice a flight, probably with the polarization/calibration switches *locked*.

Although this is a highly preliminary conclusion, it would appear, based partly on inconsistency of the wingover and uplooker data, that the waveguide dry-nitrogen flushing is not sufficient and is also inconsistent. Parts of the window units are below freezing during flight, and therefore other parts are near the freezing point of water, where the losses are high but the vapor pressure is very

low. Thus, some of the moisture may never be flushed out with the dry nitrogen, and may move around in the microwave plumbing as component temperatures change. In the future, it is recommended that all components be kept well above freezing and more thoroughly flushed.

2. 4.6 H channel

The 4.6 cm horizontal polarization channel of the SMMR simulator is known to have a major sidelobe at about the same magnitude as the main beam, aimed ahead of the aircraft wings and about 80° from nadir. This makes the channel all but useless, and the calibration should not be taken seriously.

3. 1.7 H & V channels

There is a strong oscillation present in the antenna signal output of the 1.7 cm radiometers. The period of the oscillation is about 1 minute and steady. The amplitude varies slowly with time, and represents a maximum peak-to-peak radiance of about 40K. While digital filtering for this fault may be possible, we have chosen at this time to work with data averaged over one-minute intervals for purposes of analysis. The calibration was also carried out with data averaged for one minute periods for these channels.

4. Error budget

The self-consistent fit of the data used in determining the set of interim calibration constants presented here is within 1% in most cases. The data base used is too limited to be more precise in estimating errors. A more meaningful estimate of errors will result from subsequent analysis of the calibrated data set and from the laboratory measurements now in progress.

5. Wingover results

The reader is cautioned not to be come alarmed at the wide variations in the calculated wingover data shown in Table IV. There are a variety of reasonable explanations for the large range of values too numerous to detail for each example here. Most of the high radiances can be accounted for by insufficient time for both H & V channels during the wingover maneuvers. Some of the

high values may be due to insufficient dry-nitrogen flushing of the waveguides; this will be investigated further by comparisons with the uplooker data after the entire data set has been processed.

Table I

SMMR Simulator Calibration Constants

γ, P	A	B	C	b_1	b_2	t_{H0}	c_1	c_2	t_{w0}
4.6 H	353.58	-419.43	113.54	.4910E-02	.2034E-04	310.5	0	0	0
V	350.37	-399.17	101.24	.4844E-02	.3647E-05	310.5	0	0	0
2.8 H	320.35	-332.18	0	.4591E-02	.2398E-04	297.5	-.1956E-03	-.4074E-05	300.2
V	296.86	-296.86	0	.4414E-02	-.9984E-05	297.5	-.1192E-03	-.2333E-05	302.6
1.7 H	407.98	-470.47	0	.8013E-02	-.6951E-04	298.4	0	0	0
V	420.14	-387.84	0	.6796E-02	-.9598E-04	298.4	-.1233E-02	-.2476E-04	309.5
1.4 H	295.40	-255.99	0	.4266E-02	.1961E-04	309.5	-.8407E-03	-.3074E-05	284.6
V	290.13	-252.26	0	.4552E-02	.2085E-04	309.5	-.9216E-03	.2897E-05	305.0
UP	340.22	-334.96	0	.5247E-02	.1664E-03	309.5	-.6707E-03	.1801E-05	306.1
0.8 H	331.70	-330.81	0	.3387E-02	-.1443E-03	302.6	-.4418E-03	.3539E-05	298.3
V	312.19	-257.68	0	.3732E-02	-.9885E-04	302.6	-.6207E-03	.1289E-05	300.7
UP	356.42	-412.83	0	.4679E-02	-.7247E-04	302.6	-.7667E-03	.1026E-04	303.4

Table I (Continued)

SMMR Simulator Calibration Constants

λ, P	d_1	d_2	t_{s0}	e_1	t_{R0}	f_1	t_{c0}
4.6 H	0	0	0	-.000620	250	2.01E-03	77.2
V	0	0	0	-.000177	250	1.70E-03	77.2
2.8 H	-.1300E-03	.6607E-05	297.1	-.001458	250	1.19E-03	77.2
V	-.7072E-04	.3370E-05	296.9	-.000828	250	1.33E-03	77.2
1.7 H	0	0	0	-.002282	250	1.06E-03	77.2
V	-.2364E-03	-.3791E-04	297.3	-.002889	250	1.51E-03	77.2
1.4 H	0	0	0	-.001592	250	2.15E-03	77.2
V	0	0	0	-.000888	250	1.61E-03	77.2
UP	0	0	0	-.001060	250	1.81E-03	77.2
0.8 H	0	0	0	-.001850	250	1.61E-03	77.2
V	0	0	0	-.002555	250	1.42E-03	77.2
UP	0	0	0	-.002610	250	1.28E-03	77.2

Table II

$$\text{Coefficients for } \frac{dN}{dt_c} = \frac{\partial N}{\partial C_c} \frac{\partial C_c}{\partial t_c} = \frac{\delta}{(C_c - \gamma)^2} \cdot G = f_1$$

λ, P	δ	γ	G
4.6H	.3029E04	.5528E03	-22.23
V	.2550E04	.3804E03	-23.66
2.8H	.2600E04	.5533E03	-38.77
V	.3000E04	.3957E03	-38.78
1.7H	.1730E04	.6296E03	-28.85
V	.2460E04	.5642E03	-29.35
1.4H	.5314E04	.6057E03	-45.06
V	.4002E04	.5710E03	-45.08
0.8H	.3848E04	.998E03	-44.79
V	.3382E04	.5482E03	-44.80
1.4Up	.4611E04	.4662E03	-44.62
0.8Up	.3152E03	.3592E03	-44.79

Table III

<u>λ, P</u>	<u>ϵ_{FY}</u>	<u>ϵ_{MY}</u>	<u>(ϵ^*)</u>	<u>τ</u>	<u>$\Delta T_B =$ $\tau(T_A - \epsilon T_S)$</u>
4.6 H	.84	.84	.84		.83
V	.97	.97	.97	.0278	-.07
2.8 H	.84	.81	.83		.94
V	.97	.94	.96	.0288	0
1.7 H	.84	.73	.79		1.45
V	.97	.86	.92	.0340	.34
1.4 H	.84	.70	.77		2.11
V	.97	.80	.89	.0444	.78
0.8 H	.95	.65	.80		2.88
V	.97	.69	.83	.0720	2.34

Assume $T_s = 250K$; $T_A = 240K$

*(50% FY & 50% MY)

Table IV
Sky Radiances (Kelvins) Obtained during Aircraft Wing-over
Maneuvers on the Days/Times Indicated

* = Reference Calibration Data
" = Waveguide temperatures not available
--- = Data Missing

	181/20:23	192/22:52	193/20:52	223/19:11	254/06:17	258/07:45	259/06:48	264/18:33	279/04:13
4.6H	---	---	---	25.2	24.5	23.9	27.2	19.0	11.1
4.6V	---	---	---	27.7	28.4	26.8	29.8	20.5	13.9
2.8H	.1	"40.0	31.1	"6.6	8.1	"5.4	"8.3	"-43.8	9.7
2.8V	3.0	13.8	15.0	7.2	8.7	1.5	11.8	11.2	12.6
1.7H	-11.3	64.7	65.3	*2.7	15.6	---	---	---	9.8
1.7V	-1.0	12.4	18.3	*2.7	-2.4	99.1	---	---	5.8
1.4H	59.7	.9	1.3	-1.3	1.3	1.2	2.0	3.3	-1.3
1.4V	9.2	9.1	11.2	6.1	6.2	8.4	7.2	7.0	*2.7
0.8H	-20.2	12.7	---	1.3	17.3	---	15.6	18.9	*2.7
0.8V	---	-3.9	---	-8.2	-2.6	-3.8	-2.2	3.5	-4.1

	279/19:53	279/19:55	298/19:36	299/18:04	301/17:05	303/17:55	313/21:08	322/00:43	323/23:58
4.6H	---	---	9.6	*2.7	4.8	15.1	20.6	31.6	21.3
4.6V	21.2	16.7	8.7	4.1	*2.7	15.8	21.1	38.9	12.9
2.8H	42.2	33.5	"24.1	"36.8	18.9	*2.7	39.4	41.4	29.0
2.8V	23.7	22.6	9.4	23.3	13.3	*2.7	22.0	29.5	26.4
1.7H	105.4	71.5	79.0	71.0	66.9	68.6	67.3	86.7	77.9
1.7V	37.9	20.9	25.0	16.6	29.4	44.7	-6.6	32.8	15.9
1.4H	10.4	7.4	*2.7	5.9	5.2	-.5	.9	4.5	3.2
1.4V	15.0	14.3	5.9	7.3	8.3	3.9	6.6	9.2	9.7
0.8H	35.6	29.6	15.4	20.3	17.7	12.6	21.7	29.4	26.1
0.8V	4.0	3.6	*2.7	6.3	8.0	-.6	.8	5.4	-.1

Table V

Data for Determination of A, B & C

λ, P	W/O DAY#	W/O N_1^*	ΔN_1	FY-ice N_2^*	ΔN_2	Open H_2O N_3	ΔN_3
4.6H	299	1.289	.009	.333	-.005	.762	.005
V	301	1.302	.003	.344	-.001	.779	.001
2.8H	303	1.035	.079	.369	.081	---	---
V	303	1.144	.066	.331	.067	---	---
1.7H	223	.897	.036	.406	.017	---	---
V	223	1.108	.032	.445	-.058	---	---
1.4H	298	1.162	.019	.263	-.013	---	---
V	279	1.156	.015	.263	.004	---	---
0.8H	279	1.009	.014	.300	-.001	---	---
V	298	1.264	.063	.308	-.002	---	---

$T_{B1} = 2.7, T_{B2} = 224.9$ for all λ except 0.8 cm where $T_{B2} = 232.3,$
 $T_{B3} = 101.1$

(all in Kelvins)

* $\Delta N_i \equiv M_i - N_i$ (See Equation (101))

Table VI

Open water observations during 45° right bank.

λ, P	Observed T_B	Theoretical T_B (Specular water, no atmosphere)
4.6H	125.4*	101.1
V	123.4*	101.1
2.8H	108.4	107.0
V	111.8	107.0
1.7H	128.4	118.7
V	113.4	118.7
1.4H	125.8	123.3
V	125.0	123.3
0.8H	163.2	144.7
V	157.3	144.7

*Before nonlinearity correction in M

BIBLIOGRAPHIC DATA SHEET

1. Report No. 80564	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle INTERIM CALIBRATION REPORT FOR THE SMMR SIMULATOR		5. Report Date	
		6. Performing Organization Code	
7. Author(s) P. Gloersen and D. Cavalieri		8. Performing Organization Report No.	
9. Performing Organization Name and Address Laboratory for Atmospheric Sciences (GLAS) Goddard Space Flight Center		10. Work Unit No.	
		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address NASA/Goddard Space Flight Center Greenbelt, Maryland		13. Type of Report and Period Covered TM	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract The calibration data obtained during the FALL 1978 NIMBUS-G underflight mission with the Scanning Multichannel Microwave Radiometer (SMMR) simulator on board the NASA CV-990 aircraft have been analyzed and an interim calibration algorithm developed. Data selected for this analysis consisted of in-flight sky, first-year sea ice, and open water observations, as well as ground-based observations of fixed targets while varying the temperatures of selected instrument components. For most of the SMMR channels, a good fit to the selected data set was obtained with the algorithm.			
17. Key Words (Selected by Author(s))		18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*